I. **TITLE:** Evaluation of New Innovations in Rubber Modified Asphalt Binders and Rubberized Asphalt Mixes for Nevada DOT

II. **PROBLEM DESCRIPTION**:

Nevada DOT, among many other DOTs, has been using polymer modified binders for many years. The feasibility of the use of other modified binders (e.g., rubberized asphalt) has been investigated for limited number of modified asphalt binders used in the state. Researchers have shown some promising results for performance of the mixes. However, factors in selecting and producing the rubber modified binders have not been studied in detail. These factors affect the rheological properties of the modified binder and performance of the asphalt mixtures. Furthermore, since the time of the use of these materials, there have been many new developments in the implementation of these materials.

For many years, polymers have been incorporated into asphalt as a way to mitigate many major causes for asphalt pavement failures, including permanent deformation at high temperatures, low temperatures cracking, fatigue cracking and stripping damage. These polymer modified asphalt (PMA) binders also have been used successfully at locations of high stress (e.g., interstates, intersections, etc.). PMA, for several years, has proven itself to be an essential element in the paving process in many part of the world. There are several types of polymers used in asphalt binders today. Currently, in the United States, the most commonly used polymer (over 80% around the country) for asphalt modification is the SBS (styrene butadiene styrene) followed by other polymers such as GTR (ground tire rubber), SBR (styrene butadiene rubber), EVA (ethylene vinyl acetate) and polyethylene.

Although they cost more than conventional binders, SBS-modified asphalt binders have been utilized for many years by many State DOTs. The high cost associated with the SBS modification process is mostly due to the shortage of Butadiene which affects the supply of SBS-modified asphalt binders. Therefore, it is important to have some alternative modifiers such as GTR, to substitute for SBS in asphalt binders in the future.

Rubberized asphalt mixtures use a type of modified asphalt binder with improved temperature susceptibility and flexibility. This modified binder is formed by the interaction of crumb rubber with asphalt binder at elevated temperatures for a certain period of time. This type of modified binder has several advantages including: a) increase binder's elasticity at moderate and high temperature, and b) increase binder's flexibility at low temperature. Therefore, use of crumb rubber modified (CRM) binder in asphalt mixtures improves the resistance to permanent deformation, fatigue and low temperature cracking.

Crumb rubber can be produced in almost any particle size from large aggregate sized particles to fine powder by employing several different production methods (i.e., ambient shredding or cryogenic grinding). Percentages of crumb rubber and reaction time also have significant impact on the properties of CRM binder. The crumb rubber particles absorb asphalt binder and swell with the amount being dependent on the nature, temperature and viscosity of the asphalt. The swelling of crumb rubber is a diffusion process and increases the dimension of the rubber network until the concentration of asphalt uniform and equilibrium swelling is achieved. This complex process affects the performance grade (PG) of rubberized asphalt binder, especially, as rubber size, type, and blending process are different; therefore, these topics must be investigated with local binders and aggregate sources. In recent years, many new developments have been initiated. One of these is the creation of “pellets” which is a high performance binder made of a unique blend of premium quality asphalt cement, crumb rubber, hydrated lime and other special additives. The pellets are transported and stored at ambient temperature, thus saving enormous amounts of energy normally required to keep the asphalt as a molten liquid. This energy savings also greatly reduces CO_2 emissions.

This proposed research addresses the following critical research clusters: (1) Infrastructure and Materials; (2) Data-Driven Decision Making; and (3) Economics.

III. **OBJECTIVES:**

The objective of the proposed research project is to determine the feasibility of replacing SBS modified asphalt binders by laboratory blended GTR, terminally-blended GTR following NDOT specifications, or other CRM products to meet the rheological and engineering properties of asphalt modified binders and mixtures. The specific objectives of the research project will include the following:

- Determining initial recommendations for terminally-blended GTR mix design guidelines based on the literature review and basic laboratory test results.
- Investigating the rheological characteristics of various crumb rubber types (e. g. AR, -20, -40, pellets (A and B: Pellet Concentration and PelletPAVE) and terminal blend) at high, intermediate, and low performance temperatures through the performance of AASHTO M 320, TP 70, TP 79, PP 61, and any other NDOT’s specification requirements.
- Investigating the effects of various rubber modifiers on Superpave mix design including the mix volumetric properties such as air voids, %VFA, %VMA, and optimum asphalt binder.
- Determining the moisture susceptibility, permanent deformation, dynamic modulus, flow number characteristics of various alternate modifiers with hydrated lime.
- Developing recommended specifications for Nevada DOT regarding the utilization of these materials.

IV. **CUREENT PRACTICE and RELATED RESEARCH:**

Nevada DOT has been using SBS modified binders for many years. The utilization of other modified binders (e.g., rubberized asphalt) has been investigated with some mixed results. However, since the time of the use of these materials, there have been many new developments in the implementation of these materials.

V. **RERESEARCH METHODOLOGY:** The project will be conducted in five tasks.

Task 1. Conduct an extensive literature review on the topic of terminal blended rubber asphalt binder and the utilization of rubberized asphalt binders around the country. This will result in initial recommendations for terminally-blended GTR mix design guidelines following NDOT specifications based on the literature review and basic laboratory test results.

Task 2. Investigate the high temperature rheological properties of original rubberized asphalt binders. Virgin (unmodified) asphalt cement from several different sources will be mixed with different types of CRM in different percentages and then rheological property tests will be conducted on the modified asphalt binders. The testing procedures will include all SHRP tests for quality control of original asphalt binders (AASHTO T48, AASHTO T316 and AASHTO T315) plus added tests required by Nevada DOT (Nev. T730, Nev. T745 Nev. T745).

Task 3. Investigate the high temperature rheological properties of rubberized asphalt binders from Task 2 after aging in rolling thin film oven (RTFO). This will assess the major effects of a short term aging procedure on rheological properties of these binders. The testing procedures will include essential tests for SHRP and Nevada DOT specifications plus Multiple Stresses Creep Recovery (MSCR) test – AASHTO TP70.

Task 4. Investigate the low temperature rheological properties of rubberized asphalt binders after aged by RTFO and pressure aging vessel (PAV). This will assess the major effects of a long term aging procedure on rheological properties of these binders.

Task 5. Investigate the properties of asphaltic mixture produced with the rubberized asphalt binders. Superpave mix designs will be performed for rubberized mixtures using selected two aggregate sources, selected seven binder sources, and one solid Anti Stripping Agent (ASA) in accordance with the conventional hot mix asphalt mix procedures in terms of Superpave volumetric analysis and following Nevada DOT specifications. In addition, the effects of selected crumb modified binders on Superpave mix design with respect to VMA, VFA, optimum binder content, etc. will be investigated. Any recommended changes to mix design procedures for crumb rubber modified mixes will be provided to DOT in the interim and final reports. The following testing procedures will be followed: a) Moisture susceptibility/without freeze-thaw resistance – AASHTO T 283; b) Rut Resistance – AASHTO TP 63 (APA); c) Dynamic modulus and flow number - AASHTO TP 79; Fatigue life, AASHTO T 321; and d) Dynamic modulus master curves - AASHTO PP61.

VI. **IMPLEMENTATION POTENTIAL:**

This proposed project is followed by the 2nd phase of the research deployment program. The findings of the proposed research will result in deliverables that are ready for implementation as a users guide.

VII. **URGENCY AND PAYOFF POTENTIAL:**

Due to financial reasons, many State DOTs are considering the use of alternate modified binders. The shortage of SBS around the country several years ago also has accelerated the need for development and use of other modifiers including ground tire rubber. Using the scrap tire as a waste material in rubberized asphalt binders and mixtures is a sustainable alternative.

VIII. **ESTIMATED BUDGET:**

This is a 3-year project: **$130,000** for the first year for Task 1 and parts of Tasks 2 and 3; **$130,000 per year** for the next two years for completion of the remaining tasks.

IX. **DATE AND SUBMITTED BY:**

February 22, 2013. **Dr. M. Karakouzian**, PhD, PE, Professor of Civil Engineering, University of Nevada Las Vegas, Department of Civil and Environmental Engineering, 4505 Maryland Parkway, Box 454015, Las Vegas, NV 89154-4015 Tel: 702-895-0959, Fax: 702-895-3936, email: mkar@unlv.nevada.edu; **Dr. Serji Amirkhanian**, Associate Graduate Faculty, UNLV; and **Mr. Mehdi Khalili**, Doctoral Graduate Student, UNLV.

X. **NDOT CHAMPION, COORDINATION AND INVOLVEMENT:**

Mr. Reid Kaiser, Chief Materials Engineer, NDOT, and Mr. Charlie Pan, NDOT